Research of Flight Characteristics of Rod-Type Projectile with Triangular Cross-section

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Outline

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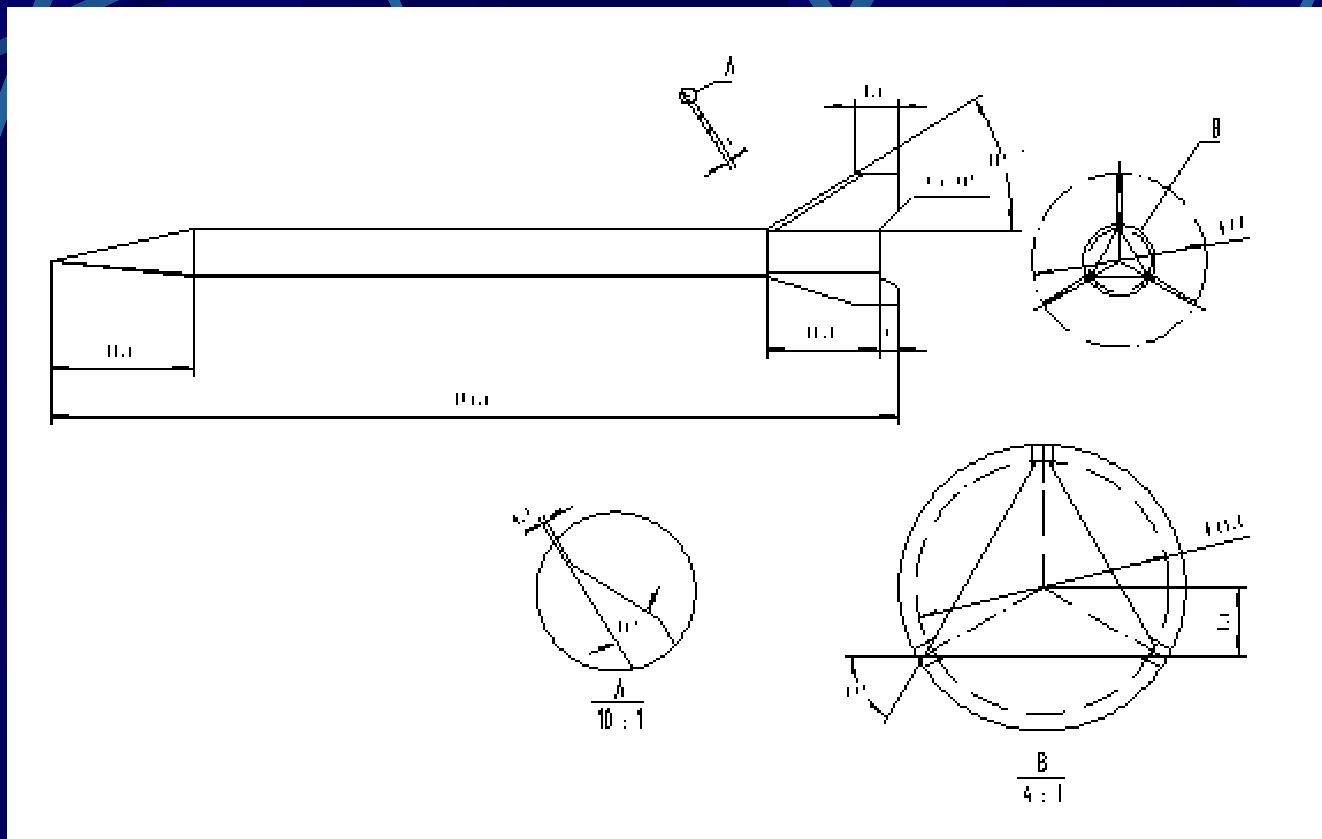
- EXPERIMENT RESEARCH
- ANALYSIS OF FLIGHT PERFORMANCE
- CONCLUSIONS

INTRODUCTION

Recently, the projectile with non-circular cross-section has paid more and more attention. for example guidance projectile, the changing of the shell shape from common circular to non-circular cross-section makes it possible to improve projectiles storage, transport, discarding and aerodynamic characteristics. The experiments prove that the non-circular cross-section has better rigidity in the same area and lighter in the same length. This paper takes armor-piercing projectile for example, contrasting and researching the aerodynamic characteristics and trajectory characteristics of triangular cross-section projectile and circular cross-section projectile respectively.

EXPERIMENT RESEARCH

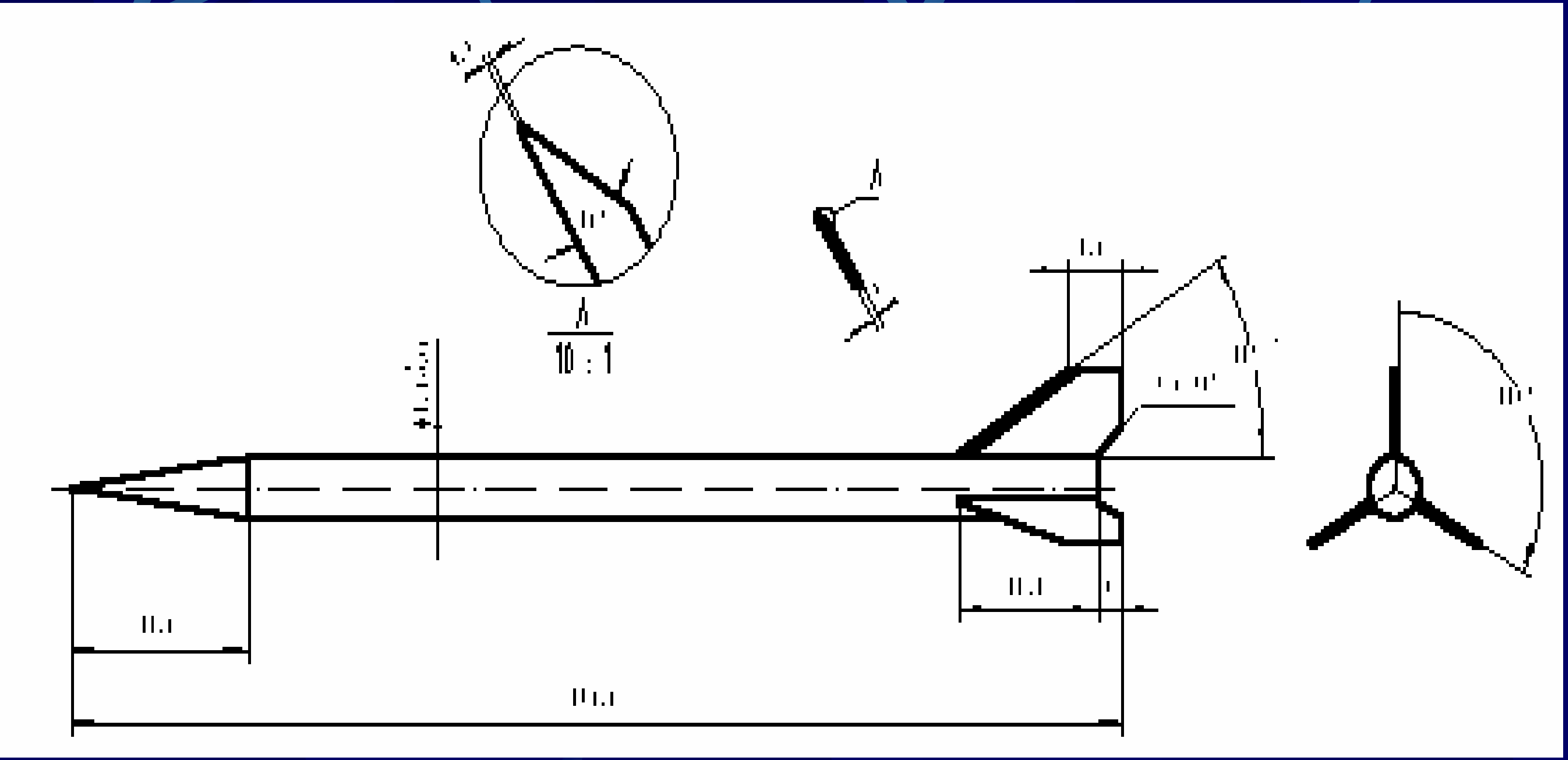


The structure of triangular cross-section projectile

EXPERIMENT RESEARCH

Triangular cross-section projectiles

EXPERIMENT RESEARCH

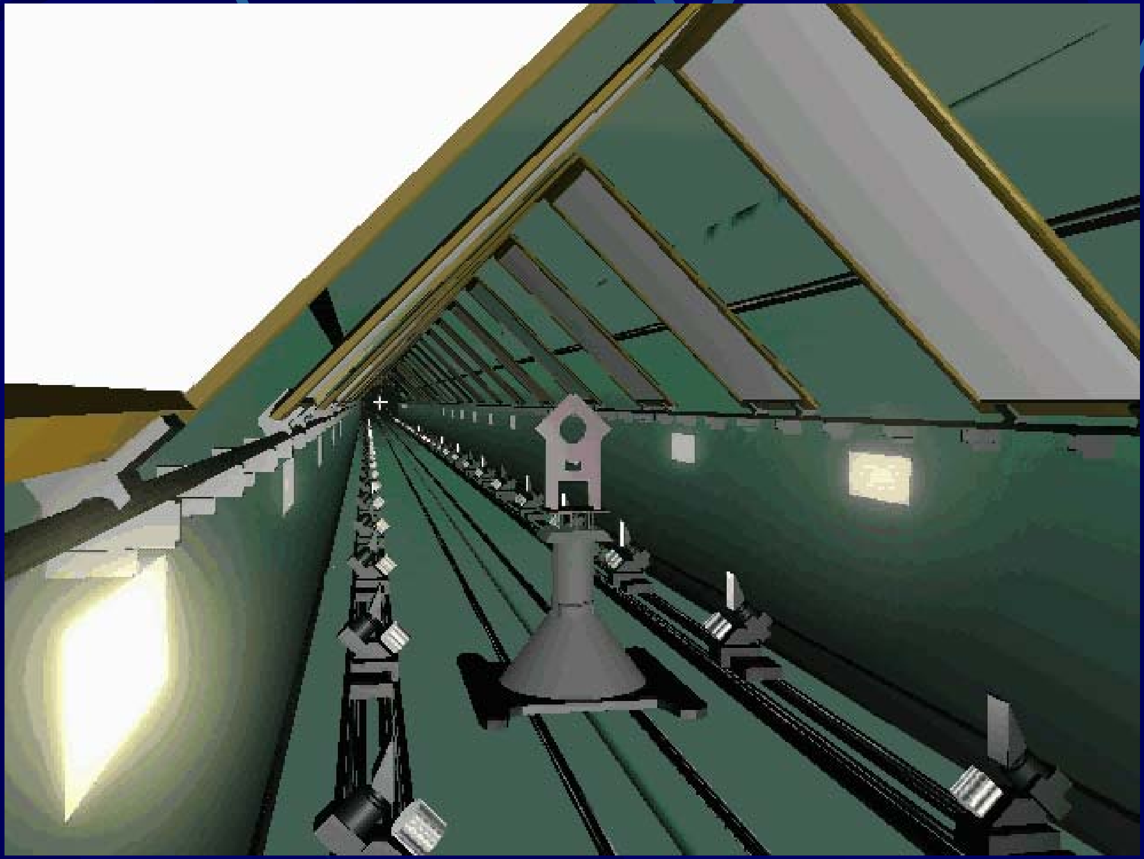


The structure of circular cross-section projectile

EXPERIMENT RESEARCH

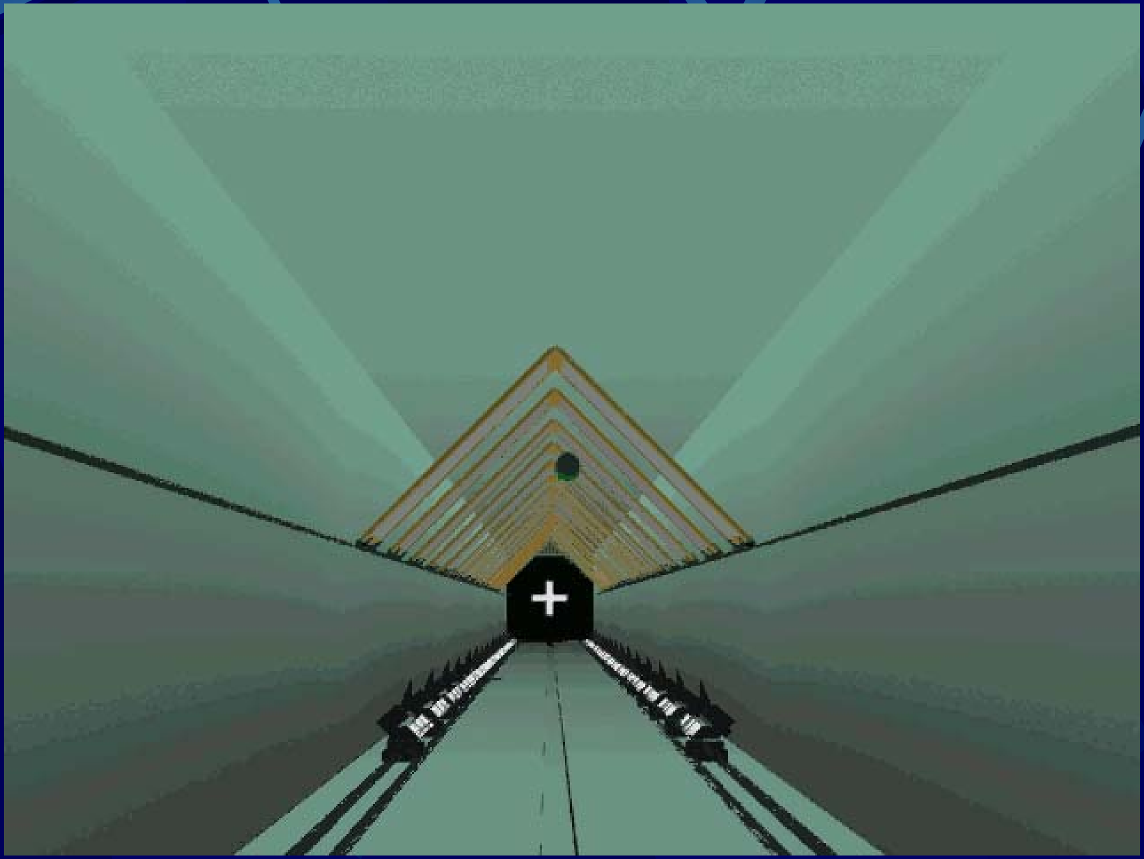
Circular cross-section projectiles

EXPERIMENT RESEARCH



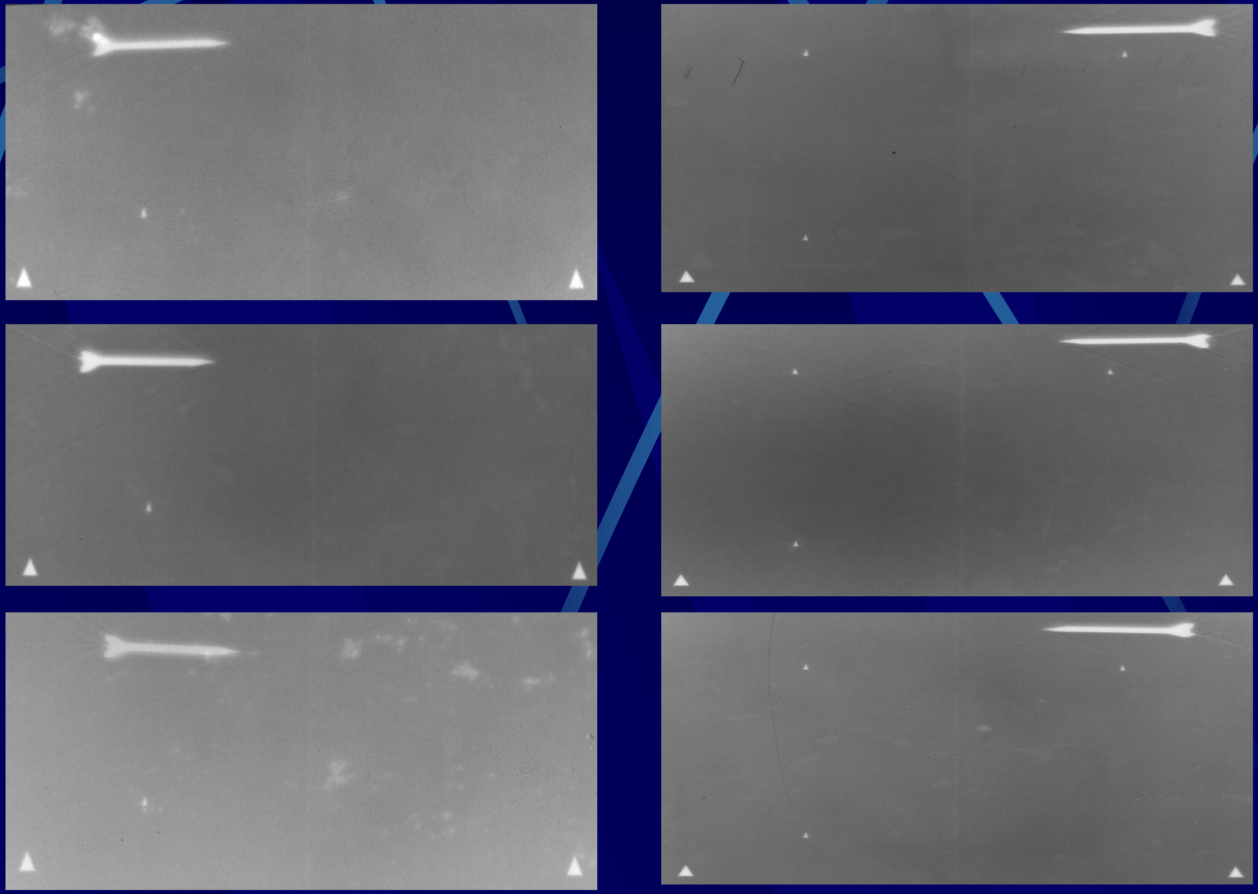
Range show

EXPERIMENT RESEARCH



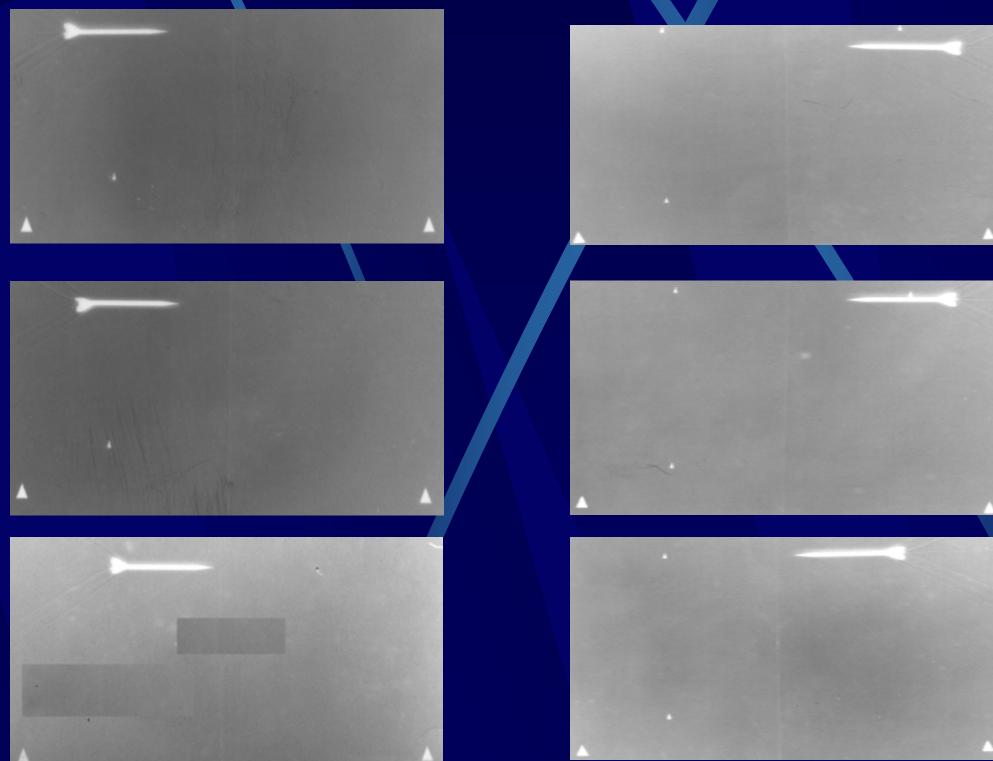
Experiment show

EXPERIMENT RESEARCH



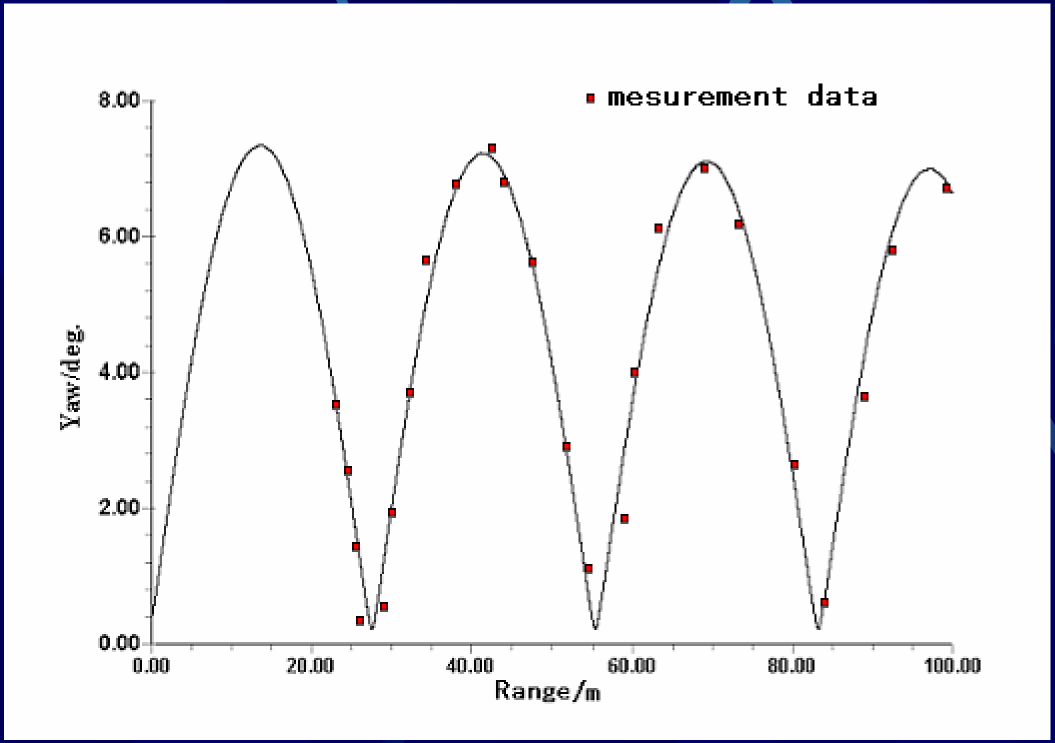
Shadowgraphic image of triangular cross-section projectile

EXPERIMENT RESEARCH



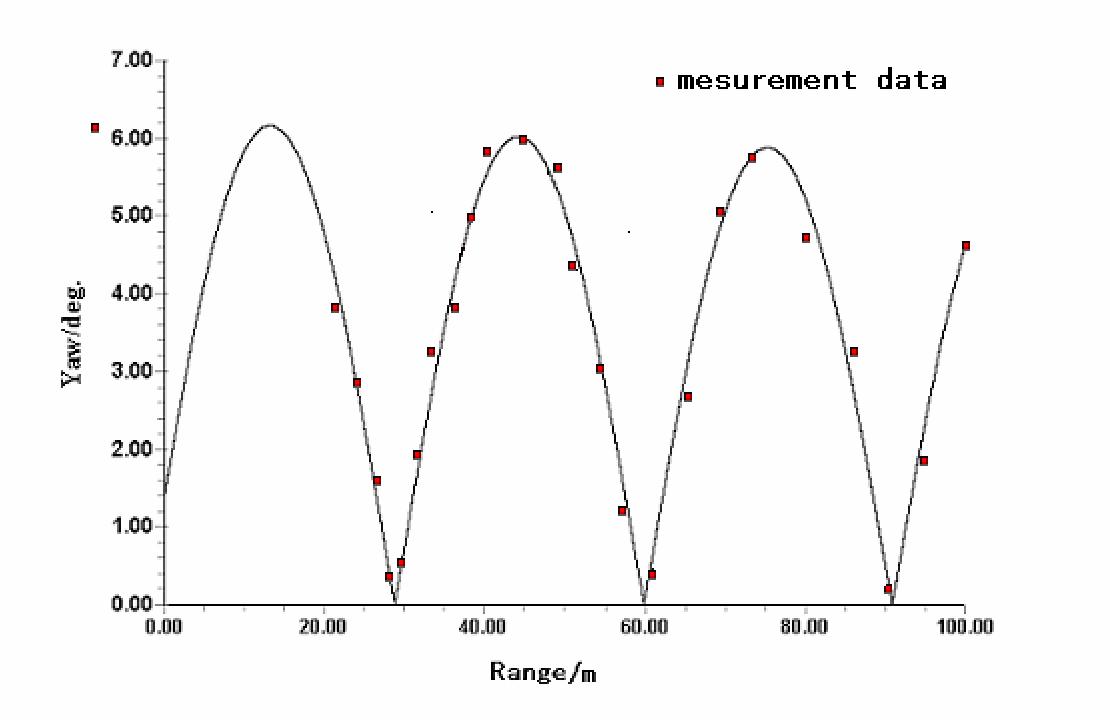
Shadowgraphic image of circular cross-section projectile

EXPERIMENT RESEARCH



Yaw angle curve of triangular cross-section projectile

EXPERIMENT RESEARCH



Yaw angle curve of circular cross-section projectile

EXPERIMENT RESEARCH

Table 1. The result of the experiment

item	No.1	No.2	No.3	No.4	No.5	No.6
Shape	Circular	Triangular	Circular	Triangular	Circular	Triangular
Mach	1.8514	1.9302	1.8996	1.9101	1.9034	1.8954
c_x	0.384	0.367	0.379	0.356	0.378	0.362
c'_y	2.387	2.764	2.475	2.661	2.296	2.736
m'_z	-2.683	-3.678	-2.676	-3.539	-2.737	-3.791
m''_y	-0.0036	-0.0038	-0.0031	-0.0038	-0.0041	-0.0052
m'_{zz}	2.472	2.463	2.397	2.517	2.413	2.529

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m'_{zz}	2.472	2.463	2.397	2.517	2.413	2.529
m'_{xz}	0.0025	0.0035	0.0024	0.0034	0.0024	0.0034
m'_{xw}	0.0024	0.0034	0.0024	0.0035	0.0025	0.0034
v_0	648.73	675.14	665.20	670.20	666.93	663.76
λ	62.08	55.71	61.79	54.94	61.44	54.17
δ_m	6.17	7.43	6.46	6.87	6.03	6.62

ANALYSIS OF FLIGHT PERFORMANCE

According to the aerodynamic coefficients of the projectile gained by experiments, contrasting and analyzing the triangular cross-section projectile and circular cross-section projectile in fight performance such as resistance characteristic, stability under low speed rotation, maneuverability and so on.

ANALYSIS OF FLIGHT PERFORMANCE

Table 2 shows the analysis result of triangular cross-section projectile and circular cross-section projectile in static stability.

Table 2. Static stability contrasts

Content	m_z^{δ}	c_y^{δ}	$m_z^{c_y}$	$f\,(hz)$	$T(ms)$	$\lambda(m)$
Triangular	-3.678	5.528	0.6653	75.49	83.23	55.71
Circular	-2.813	4.622	0.6086	69.37	90.57	60.13

(Notes: $\left|m_z^{c_y}\right| = \dfrac{\left|m_z^{\delta}\right|}{c_y^{\delta}} = \dfrac{l_{pc} - l_{mc}}{l} \times 100\%$, stand for static stability allowance)

ANALYSIS OF FLIGHT PERFORMANCE

The analysis and results shows that static stability allowance of triangular cross-section projectile is higher than circular cross-section projectile, its stabilizing moment and dumping moment is bigger than circular cross-section projectile, especial the stability moment.

To triangular cross-section projectile, the oscillatory frequency is higher and the oscillatory wavelength is short. These characteristics represent that the stability of triangular cross-section projectile is better.

ANALYSIS OF FLIGHT PERFORMANCE

Table 3 shows the analysis result of triangular cross-section projectile and circular cross-section projectile in stability characteristic under low speed rotation.

Table 3. Stability characteristic contrasts

Content	$I_x\,(kg.m^2)$	$m_x^{\delta_\omega}$	m_y^{α}
Triangular	0.0986×10^{-5}	0.00343	-0.0038
Circular	0.0979×10^{-5}	0.00245	-0.0032

ANALYSIS OF FLIGHT PERFORMANCE

The analysis and results shows: the Magnus moment of triangular cross-section projectile is higher than circular cross-section projectile. To the projectile in flight, the Magnus moment is disturbance moment. The bigger of Magnus moment, the bigger interaction of pitching and yaw by rolling, maybe it will lead to great distribution. So the effect of reduce offcenter and initial disturbance of triangular cross-section projectile by low speed rotation is not as well as circular cross-section projectile.

ANALYSIS OF FLIGHT PERFORMANCE

Table 4 shows the triangular cross-section projectile and circular cross-section projectile in maneuverability. The analysis and results shows: the drag coefficient of triangular cross-section projectile is lower than circular cross-section projectile's, the triangular cross-section projectile has higher lift-drag ratio, and could supply bigger normal overload, consequently it has better maneuverability.

Table 4. Maneuverability contrasts

Content	c_{x0}	c_N^{δ}	$(L/X)_{max}$
Triangular	0.366	0. 3093	2.197
Circular	0.378	0.2686	1.901

CONCLUSIONS

- The projectile with triangular cross-section has smaller flight resistance, less kinetic energy loss, higher ratio of kinetic energy to cross section area when impacting.

- The projectile with triangular cross-section has better static stability and it's static stability allowance is bigger than the circular cross-section projectile's.

CONCLUSIONS

- Under low speed rotation, the projectile with triangular cross-sections has great Magnus moment and more possible to increase the projectile dispersion.
- The projectile with triangular cross-section has higher lift-drag ratio, could supply bigger normal overload and better maneuverability. Therefore it’s more suitably used for projectile missile shape.